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ENVIRONMENTAL INDICATORS

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Abstract: Many environmental indicators have been accepted within the tourism industry. However while purporting to represent the environment, indicator research fails to evaluate the ecological impact of tourism. There are well-founded reasons for this failure, including the ambiguous character of science, which promises a regulatory regime for managing the environmental impact of tourism, but which cannot be delivered. To illustrate this dilemma, the difficulties involved in developing bio-indicators for a coral reef are discussed. The inconclusiveness of current knowledge is illustrated and attention drawn to the disturbing implication that the present situation offers little protection when called upon in the arbitration of land use decisions. **Keywords:** bio-indicators, environment, sustainable tourism, coral. © 2002 Elsevier Science Ltd. All rights reserved.

Résumé: Les indices écologiques s'utlisent de plus en plus dans le tourisme. Cependant, tout en se vantant de préférencier l'environnement, les recherches sur les indices écologiques ne mesurent pas l'impact écologique du tourisme. Il y a des raisons biens fondées pour ceci, y-inclus le charactère ambigu de la science. Les promesses d'un régime régulatoire sur l'impact sur l'environnement ne peuvent se réaliser. Comme illustration de cette ambiguité, nous présentons les difficultés de développement des indices de l'état biologique pour un récif de corail. L'inconclusivité des indices dans l'état actuel de nos connaissances est démontrée, et nous attirons attention au fait déconcertant que ces indices n'aident pas à protéger le milieu naturel dans les arbitrations sur l'utlisation du sol. **Mots-clés:** bio-indicateurs, environnement, tourisme soutenable, corail. © 2002 Elsevier Science Ltd. All rights reserved.

INTRODUCTION

This paper grows out of a research project, which explored the feasibility of constructing environmental indicators for tourism (Furley, Hughes and Thomas 1996). The original research was motivated by a sociological assertion about how social agendas are constructed. In outline, it supposes that public affairs discourse is conducted in ways that markedly differentiate it from private and domestic discourse—in particular its rational lines marginalize the display of emotion and affect. In public discourse, facts and figures tend to be privileged over qualitative arguments, which may be dismissed as the product of "self-deception" and the "prejudice" of affect. But, there is a relative paucity of facts and figures to report the environmental performance of tour-

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ism compared to the voluminous data for monitoring its economic performance. Hence, it may be argued, the environment is at a disadvantage when it comes to the public evaluation of tourism (Hughes 1991, 1995). This data deficiency acts either to silence the environmental side of the tourism-environment debate, through lack of factual information with which to contest the quantitative facts of economic importance, or to marginalize it to the untrustworthy domain of "emotion" and "prejudice".

However, as with earlier attempts to develop empirical estimates for recreational carrying capacity (Colgan 1978; Coppock and Duffield 1975; Dartington Amenity Research Trust 1973; Foin, Garton, Bowen, Everingham and Schultz 1977; UNESCO 1972; Wall 1979) this project encountered confounding factors sufficient to raise speculation about the feasibility of developing environmental indicators for tourism. But this experience contrasts markedly with the prevailing mood of the industry. Here there is general optimism about the ability to devise environmental indicators founded on two compelling views. On the one hand, the literature of tourism management marshals social exhortations about "responsible" development under the theme of "sustainable tourism". On the other, the application of science to the task of environmental management offers the promise of explanation and hence the ability to regulate and control impacts. These views are complementary, since a belief in the efficacy of the rational method of science underwrites management aspirations to regulate tourism in a sustainable way, and there is apparent certainty that scientific research into environmental indicators will furnish management with the necessary monitoring data (Andersen 1991; Environmental Challenge Group 1994; Local Government Management Board 1995; McGillivray and Zadek 1995; Pearce, Markandya and Barbier 1994; UN Commission on Sustainable Development 1996).

Such confidence in the emergence of more sustainable forms of tourism has, of course, drawn its critics who point to the profit motivation of global capitalism and its disposition to expand, rather than moderate, tourist consumption (Britton 1982; Mowforth and Munt 1998; Shaw and Williams 1994). For such critics, talk of "sustainability" manifests false consciousness or bad faith. But tourism is more multifaceted than this and, while it demonstrably destroys environments, there are well-founded reasons to believe that it can also be a force for protection. This paper takes a critical perspective on the sustainability of tourism but from a more "technical", or ecological, point of view than the critiques of consumer capitalism. It will explore the limitations of sustainable tourism, paradoxically, as a strategic response that purports to protect the environment, but may in practice expose it to increased risk. The limitations are familiar enough to environmental scientists. Yet, it will be argued, they are not acknowledged in the proliferation of sustainable tourism strategies, and they do not temper the general confidence with which management advances sustainability as an environmentally benign form of tourism.

But first the global tourism problem must be conventionally represented, for it is against this depiction that sustainable tourism has

emerged as "the" solution. The paper will then discuss the environmental shortcomings of sustainable tourism by focusing on two studies and their approach to the development of environmental indicators. The discussion will conclude with a review of factors which confound the development of environmental indicators and, in the light of this, raise doubts about the potency of "scientific" strategies to regulate the environmental impacts of tourism. For practical reasons, the empirical component of this research has had to be confined to one type of environment: coral reefs. This choice is justified on the basis that coral reefs are arguably some of the world's most vulnerable environments. They are of particular concern to tourism management, because of their appeal to a new and fast growing type of tourism called, appropriately enough, "new tourism" (Poon 1993).

TOURISM AND THE ENVIRONMENT

Tourism is popularly depicted as a kind of quasi-autonomous flow ("the golden hoard" "mass tourism", etc). *Spatially* this has been represented, at the global level, by a core-periphery model in which tourist flows emerge from the metropolitan centers of industrialized nations and are funneled through staging points towards destinations on the "pleasure periphery" (Hills and Lundgren 1977; Pearce 1989; Prosser 1994; Shaw and Williams 1994; Turner and Ash 1975). This, in its turn, stimulates the growth of tourism enterprise, which sets in motion the decentralization of infrastructure along local transport arteries. New development is forced outward from the original destination as a result of competition for land, raising its prices and general intensification (Cohen 1978). *Temporally*, this cumulative pattern has been given its most coherent statement in Butler's (1980) destination lifecycle thesis which proposes six stages in the evolution of a tourism area: exploration, involvement, development, consolidation, stagnation, and rejuvenation or decline. Thus, the dominant conception is that tourism is both cumulative and cyclical. The effect of this is to create a picture of a contagious flow, which threatens to overwhelm environmental and social limits by a process of creeping incorporation. Some authors consider this to be fatal for the hosts and argue that tourism is predisposed to economic exploitation (Britton 1982; Mowforth and Munt 1998) and environmental and cultural destruction (Cohen 1987; Dann 1996a; 1996b; Greenwood 1989; Selwyn 1996). Conversely, others welcome tourism for its culturally constructive contribution (Boissevain 1996), its environmental protection (Boo 1990; Pigram 1980), and positive economic impact (Woods, Perry and Steagall 1994).

This is part of a "blessing and blight" (Young 1973) ambivalence that has long been part of discussions about tourism and, while acknowledging the cultural and environmental erosion wrought by the globalization of this industry, are plausible social forces that support the aspirations to protect the environment. The rise of new tourism—in forms as diverse as ecotourism, green tourism, responsible tourism, heritage tourism, and cultural tourism—manifests the effects of deep structural transformations in Western society. Life in late modern

society is characterized by heightened levels of insecurity and anxiety (Beck 1992; Giddens 1991; Sennett 1999) promoted by transformations in the economic and social structure. The workforce is now afflicted by periodic redundancy and down-sizing as well as processes of casualization and fragmentation that favor female part-time over male full time labor. Social structures have simultaneously become less rigid in respect of class affiliation, sexual orientation, religious commitment, and the like—opening opportunities for social emancipation, but at some cost to an individual's social and psychological security. Therefore, the emerging new tourism forms may echo some of the deeper social needs that arise from the insecurity of living and working in late modern society.

In the past, Western society has used nature and heritage to shape cosmology. Nature, in Christian mythology, provides a narrative of loss in which humanity has been separated from innocence. In a more secular age, nature offers embattled citizens the psychological resources with which to recover some of the sense of lost innocence. Nature is valued for its wholesomeness and its implied moral critique of contemporary consumer society. Heritage tourism may be similarly associated with individual and social anxiety about change. The nostalgia of heritage tourism has been fiercely attacked for its social regressiveness (Hewison 1987), yet it offers myths of social and psychological identity that may be used as bulwarks against the alienation of modern life. The past offers individuals some sense of rootedness and a temporary escape from the insecurities of the present. Cultural tourism shares with nature the narrative of loss in which primitive peoples continue to live closer to nature, and thus more authentically, than in metropolitan civilization. As "noble savages" primitive people are popularly supposed to retain the vestiges of innocence that have been eroded in Western materialism.

There is then some ambiguity about the cultural and environmental impacts of tourism. Much critical debate has turned upon questioning the sincerity of the tourism industry and the materialist aspirations of consumers, but there are plausible reasons to suppose that the social and existential needs of individuals also require authentic relations with the world (Cohen 1973; 1979; MacCannell 1973). Sustainable development, the favored solution of the industry, need not necessarily be dismissed as the rhetorical cover for new middle class exploitation (Mowforth and Munt 1998). In the light of the social and psychological motivations that may be argued to drive tourism, and particularly the new tourism, it would be excessively simplistic to universally condemn globalizing tourism (Crick 1989). Grounded in deeper anxieties of social and psychological alienation, it has the potential to protect environments as well as to destroy them.

Sustainable Tourism as the Solution

Formal institutional recognition of the environmental threat posed by the growth of global tourism came in 1979 when the World Tourism Organization (WTO) established the Environment Committee to

address the issue of conservation. In 1982, it adopted a set of principles known as "the Joint Declaration on Tourism and Environment" which was prepared in conjunction with the United Nations Environment Program (Ceballos-Lascuráin 1996:15). However, it was probably the exhortations on sustainable development of the Brundtland Report (WCED 1987) and "Agenda 21" (UN 1993), that gave momentum to the specific emergence of sustainable tourism, although the issue had been aired by Mishan (1969) almost a quarter of a century earlier. As with other high level concepts, such as democracy, socialism, and environment, the concept of sustainability continues to excite opinion about its "true" meaning. The often-quoted definition of the Bruntland Report sought to reconcile the competing claims of economic development and conservation by emphasizing the need to bequeath to future generations an undiminished environmental resource. As taken up in tourism, this has been interpreted as a negotiating process between the interests of four main stakeholders: the tourist, the resident, the industry, and the environment.

The World Tourism Organization, World Travel and Tourism Council (WTTC), and the Earth Council incorporated into tourism a set of basic principles on sustainability derived from the 1992 Rio Declaration on the Environment. This revitalized management interest in the concept of environmental carrying capacity also drew attention to the need for better monitoring information to measure progress. As one of the studies that had been commissioned to address these challenges put it:

> the case against tourism is well known—that it pollutes and disfigures, corrupts traditional cultures, and overburdens local resources. Man has been destroying his own leisure habitats, never mind those of the animal kingdom, and the destruction of habitat leads to the destruction of species. But the case all too frequently is an emotive one, founded in our own prejudices and preconceptions. *Precious little science* has been brought to bear, largely because there is *precious little science available* (Hughes 1994:3).

Three international institutions that represent the interests of the tourism trade initiated indicator studies in the early 90s. WTTC published a study on the "Statistical Indicators Needed to Monitor Sustainable Travel and Tourism Development" (WTTC 1992), WTO's Environment Committee established a taskforce to investigate the development of indicators of sustainable tourism (International Working Group on Indicators of Sustainable Tourism 1993), and the International Federation of Tour Operators commissioned a study, which reported in 1994, to devise a model of sustainable tourism which included a range of performance indicators. Consideration of such indicators also occupied the attention of World Conservation Union (formerly the International Union for the Conservation of Nature and Natural Resources) as one component of a larger concern with managing the carrying capacity of tourism in nature parks and protected areas. In conjunction with WTO and the United Nations Environment Program they authored a report called "Guidelines: Development of National Parks and Protected Areas for Tourism". Following the World Park Congress in 1992, they brought out a further study with recommendations on the

management of ecotourism in protected areas (Ceballos-Lascuráin 1996). The character of this indicator development process can be illustrated by drawing on two of these exercises. Attention needs to be drawn to the facility with which both studies appear to go about the development of indicators that contrast with a range of impediments identified in research conducted on coral reefs.

Indicators for the Sustainable Management

The WTO working group report (International Working Group on Indicators of Sustainable Tourism 1993) is less easy to understand than it might be. Its clarity is compromised by the introduction of multiple terms for the same objects, often in different parts of the report, and the use of hierarchical levels of classification that are not always consistently applied. Notwithstanding this, the study succeeds in documenting, in some considerable detail, a strategy by which the sustainability of tourism might be monitored and, by inference, managed. The study recommends that indicators be developed using three categories to reflect differing policy needs. These are termed "corporate indices", "national level indicators", and "site or destination specific indicators". This three-category division forms the top level of the hierarchy of indicators. The study turns to the level of detail at which these composite, national, and local sets of indices might be reported. The working group makes recommendations, again in three parts, which reflect the largest of resources that might be available for the task. At the best-resourced level this would support a "comprehensive", or "ideal" coverage of indicators, but at progressively less well serviced levels two more modest exercises would be countenanced. Medium term or practical indicators would be a subset of the comprehensive coverage reflecting pragmatic considerations of time and money, and a minimalist set might be countenanced under conditions of severe resource constraints.

A "Comprehensive" or "Ideal" Set of Indicators. To quote the report, "such a set of indicators would respond in all respects to the need to measure the state of the environment, tourism-environment linkages, and the effects of our actions". It would include a "comprehensive *inventory of site characteristics*", "biological and physical monitoring of key qualitative and quantitative variables", "measures of the *levels of different types of tourist use* which can be sustainably supported by different ecosystems", "measures to identify the *limits of carrying capacity* for representative ecosystem types, the sensitivity of certain parts of the natural and cultural environment to different levels of use", and "comprehensive monitoring at source of the *levels of pollutant* generation by the industry and by other sectors which influence the resource base of the industry" (International Working Group on Indicators of Sustainable Tourism 1993:19–21). This latter refers to solid and liquid waste, discharge of sewage, oil spills, toxic waste discharge, air pollutants and visual pollution, loss of key resources, and the like.

On the specific issue of measuring *ecological* stress, the working group

recommended monitoring—species loss, biodiversity, ecosystem resilience, changes to critical habitats, and specific measures of chemical and physical change—as examples of key bio-indicators. However, this WTO working group was aware that in practice the production of an ideal or comprehensive set would probably be beyond available resources, so they commended the choice of a more practical set of "operational indicators" using the comprehensive long list as a context. These are variously referred to as candidate or medium term indicators.

"Candidate" or "Medium Term" Indicators. These practical indicators "cover the most important subjects at a national or regional level that tourism decision-makers need to know to build towards a more sustainable form of tourism development" (1993:19). These are subdivided into national level indicators (those to be collected and aggregated at the level of the nation), and local, or "critical area" indicators (collected for particular sites). Some 17 indicators were listed for the *national* level and those that refer principally to the physical environment have been extracted in Table 1.

Each indicator has an entry attached to it that suggests its value for informing the policymaking process. However, these are fairly circular statements producing tautologies like indicator B, which measures endangered species and would alert policymakers to the impact of tourism on biodiversity, while indicator E, measures intensity of use or tourism "hot spots" and would alert policymakers to the distribution of sites currently and potentially under stress. What they are less forthcoming about is the raft of problems deciding *when* species become endangered (that is, identifying the critical thresholds) and to what extent *tourism* is the agent responsible. The exercise is then repeated to identify "candidate indicators" at the *local* level.

Table 1. Short List of Candidate Indicators for National Level[a]

A: area protected (% of national territory)
B: endangered species (area under stress)
E: use intensity ("hot spots", UNESCO sites classed as stressed, concentration of natural features at visited sites)
F: key resource consumption (water, energy and fuel)
K: environmental standards (% of homes and hotels connected to water and sewerage system)
L: infrastructure capacity utilization (analysis of extent of overloading of water, sewage and energy systems)
O: environmental planning (what strategies and codes of practice exist for tourist operators and tourists)
P: environmental review process (evaluate effectiveness of EIA process, development application process)

[a] Source: International Working Group on Indicators of Sustainable Tourism (1993: 15–16).

Minimal of Base Level Indicators. Unfortunately, it is not clear what the characteristics of the most minimal or "base" level of indicator study might be since the report appears to make no further mention of this. It is difficult to avoid the conclusion that this is list making that has got out of control. In the appendices the Working Group identified some 73 indicators, with further subdivisions, which aspire to become the WTO international standard. However, these are overwhelmingly measures of what is available, rather than what may be required. While the environment is much spoken about in the preliminary discussion, there proves to be only the most minimal of attention to monitoring tourism impact on the *ecosystem.*

The second study of indicators was prepared within a project commissioned by the International Federation of Tour Operators. The ECOMOST study, standing for European Community Models of Sustainable Tourism, is the result of a brief to devise a planning framework within which tourism can be sustainably developed. The ECOMOST project benefited from better resourcing than the WTO working group and had the opportunity to test its recommendations in two case studies. Table 2 illustrates the basic features of the ECOMOST approach.

Taking sustainable development as its goal, the study devised a management framework within which tourism might be developed. This

Table 2. Extract of Checklists for Dangers to Sustainable Tourism[a]

Topic	Component or Target	Indicator	Critical Value
Population	Preserving the population's prosperity	Population dynamics	Continuous and major migration of working population
		Unemployment rate	
		Per capita income	
Tourism	Retaining guest satisfaction	Maintenance of quality and monitoring ecology	Persistent criticism of accommodation, overcrowding, ecological conditions, aesthetics
Ecology	Environmental consciousness	Guests aware of environmental problems	If simplest cost-free measures not taken to make accommodation more environmentally friendly
Topic	**Component/Target**	**Requirement**	
Politics	Effective tourism and ecologically orientated legislation	Existence of ecologically-orientated quality standards	

[a] Source: Hughes (1994:10–15).

implied a balance between many competing interests that were collated into four categories: population, tourism, ecology, and politics. Each category or "topic" was then considered against the management issues (called components or targets) that were seen to influence it. Thus, for example, the "ecology" of an area is effectively reduced by the extent to which its carrying capacity is compromised, "tourism" by the level of satisfaction of guests and tour operators, "population" by its prosperity, and so on. These targets were then associated with indicators that could be used to monitor performance in fulfilling the targets. One feature of this approach, which differentiates it from the WTO study, is that each indicator has associated with it a critical value. If one is triggered, it would indicate an unacceptable rate or level of change which would invite policy intervention. This is a painstaking study. It creatively defines the components of a sustainable approach, proposes means by which these may be realized, and takes account of the vagaries of political influence on the development process.

However, the ECOMOST study raises questions similar to those already discussed above. It evinces the same air of confidence in the ability of research to identify and calibrate environmental impacts and then to relate these to tourism in ways that allow decisions to be made about acceptable levels of use. Perhaps it was the difficulty in doing this for ecological impacts, rather than social and economic ones, that explains the relatively limited attention to the biosphere and bio-indicators in this study. Those suggested for ecology tend to reflect concern primarily with incommoding the industry, such as water shortage, access to attractions, and airspace, and only secondarily the impact on the ecology. Otherwise they have plausible but as yet unspecified relations with the ecology such as bland statements like "water", "soil", and "air pollution" whose impacts remain undiscussed. In the case of the indicator for the "protection of species, biotopes, and protected areas", the critical point in the process of ecological destruction is stated to be when "species are in danger of becoming extinct" and when "biotopes are becoming imperiled or being destroyed" (Hughes 1994:14). Again it seems reasonable to ask *when* such states are rendered serious enough to be confirmed as in danger of extinction and *how* is tourism causing this?

Herein lies the problem with all such studies. The confidence with which they commend the use of indicators belies the many impediments to their construction and use. These scenarios make a range of questionable assumptions: the ease with which environmental effects can be identified, the readiness with which they can then be measured, the ability to specify critical thresholds of change, the ease of linking change to tourism as its cause, the assumption of available management powers within the appropriate jurisdiction, and the will to take action after all these impediments have been satisfied. Butler captured the effects of this when he asserted that

> there are no satisfactory indicators of carrying capacity or the ability of environments to sustain tourism. All too often, the first indicator of nonsustainability is the decline of attractiveness perceived through a decline in visitor numbers, or undesired change in the human physi-

> cal environment of the destination area. In many cases such indications come too late for satisfactory remedial action, even if that had been possible (Butler 1993:39).

This is a radically opposed observation to the optimism evident in both of the above studies. The discrepancy between this, and the confident commitment to the sustainable management of tourism, begs some explanation. Many, as reviewed earlier, would explain this by accusing the industry of bad faith or misplaced optimism. While this may be true, the balance of this discussion examines a further possible explanation: that there are also good scientific reasons why environmental indicators for tourism may not be available in a timely way. There are a variety of impediments to the construction of indicators, and particularly bio-indicators, that may account for the state of affairs summarized by Butler (1993). Failure to recognize these has meant that indicator studies have effectively ignored the biosphere, assuming that measures of tourist overcrowding and perceptions of quality somehow relate to ecological change but through processes that remain unspecified. Or they have collected measures of environmental impact, such as pollution levels, but failed to offer critical values of sufficient specificity to permit their useful interpretation.

Developing Bio-Indicators

There are three possible approaches to the development of environmental indicators. Monitoring may measure directly the intensity of the stress that is put on the environment, such as the measurement of contaminants in water and air. This appears to be the favored approach of the indicator studies reviewed above, but it requires a detailed knowledge of critical or threshold levels of stress. The problem here is that knowledge is at best tentative about the critical levels of some contaminant stresses and simply unavailable for many others. The second approach—and the one evaluated in the balance of this paper—is to measure the indirect effect of stress on the environment through use of indicators or bio-indicators. This associates changes in the volume, health, and composition of selected flora and fauna with known patterns of environmental stress, such as the build up of tourism. The third method is to employ a combination of both the direct and indirect approaches.

Various authors have addressed the desirable ecological requirements of indicator species (Brown 1991; Furness and Greenwood 1993; Hourigan, Tricas and Reese 1988; Thomas 1993; Ward and Jacoby 1992). In an ideal world, indicators would fulfil the following conditions (Table 3). Of these conditions, the most fundamental is that the ecology of an indicator species, and the patterns and processes of its response to stress should be understood. If the factors bringing about change are not understood, then management can only guess at how to fix what is wrong, and the results of a monitoring program would be of little practical value. However, this critique will illustrate just how difficult it is to devise appropriate bio-indicators. It will argue that, far from producing greater certainty, these difficulties give rise

Table 3. Conditions for an Ideal Indicator[a]

- Be easy to identify and measure
- Be functionally important in the ecosystem (e.g., keystone species)
- Have a high imputed value (cultural, sociopolitical, or economic)
- Be relatively sedentary
- Have modest technological requirements
- Be sensitive to the stress in question
- Have mechanisms whose response should be understood
- Be quick to respond
- Be low in ambiguity

[a] Source: Furley, Hughes and Thomas (1996:32).

to ambiguities that undermine the value of indicators for guiding sustainable tourism development.

To focus this critique, it was necessary to restrict the case study to one ecosystem, and the coral reef system was chosen. A coral reef is a major natural spectacle that attracts skin and SCUBA (self-contained underwater breathing apparatus) divers as well as more passive sightseeing tourists. It is acknowledged to be a highly sensitive ecosystem and it has attracted a considerable quantity of scientific research. A coral reef may signal stress in a number of ways. These include changes in the growth rate, in its reproductive status, in the incidence of disease, and in the patterns of distribution and abundance of some general indicator species (Brown and Howard 1985). However, selecting indicators that will measure such stresses involves considerations of spatial and temporal scale, scope and level of detail, as well as issues involved with differentiating the sources of the stress. These issues will be explored under five themes.

Natural Perturbation. Coral reefs are subject to a variety of natural stresses that affect species abundance and distribution on a number of scales. They include small scale trivial events, such as predation and disease, up to events that may cause massive destruction over a wide area, such as tropical storms, volcanic eruptions, and El Ninõ events (Grigg and Dollar 1990; Wells 1988). Coral ecosystems have evolved to withstand such severe catastrophic dislocation and are now recognized to exist in nonequilibrium conditions. Therefore, change is a natural feature of the system. Anthropogenic stress has thus to be measured against the background of dynamic change. There being no "physiological constant", the equivalent of body temperature in mammals (Thomason and Roberts 1992), the most obvious way to account of background changes unrelated to human imposed stress is to also monitor control areas that are thought to be unaffected by their impacts. This should begin two to three years before the stress is imposed in order to determine the relationship between natural levels of variation at the two sites (Schroeter, Dixon, Kastendiek, Smith and Bence 1993). However, in practice monitoring programs are often only established in response to an anthropogenic stress that was not pre-

viously anticipated. Therefore, attempts to meet this requirement limit the choice of species and sites to those adopted in existing programs of research that can provide the appropriate baseline.

Indicators and Scale. The question of spatial scale is of critical importance in the selection of bio-indicators. Prevailing approaches tend to concentrate on measuring reef health as indicated by the percentage cover of live coral or changes in the diversity of species. However, a coral reef is an open system linked to seagrass beds and mangroves through the flow of energy, nutrients, and the reproductive migration of fish. For example, sediment and organic matter is carried from the terrestrial shoreline communities and dispersed over inner channels, coral islands, and the outer reef—while the breeding grounds and nurseries of many reef species are believed to be located in the protected inshore and wetland communities of mangrove (Blanquet, Gibson and Hatch 1994; Odum, McIvor and Smith 1982; Zisman 1998). This is a mutualistic relationship whose importance is marked by the potential for system transformation as the shoreline mangrove is lost to hotel, condominium and second home development, and the like. Thus, it is in the nature of the ecological complexity of this environment that monitors of anthropogenic stress require onshore as well as offshore indicators, which greatly expands the coverage. This adds appreciably to the costs of monitoring and may also transgress managerial jurisdictions in which the source of a stress occurs within a different jurisdiction from where its impact is finally manifested. The current trend toward coastal zone management is one step in combating this, but national frontiers exacerbate the problem.

Temporal scale is also a limiting factor for indicator development. The time-scale of the processes that structure coral reefs may not readily coincide with the temporal perspectives of reef monitoring programs. Porter and Meier argue that "at the very least [the] appropriate time scales must encompass the lifespan of the dominant members of the community" (1992:625). Rogers (1993a, 1993b) also argues for long term studies on the grounds that it is otherwise impossible to differentiate natural from anthropogenic changes. Therefore, continuous monitoring may be required over tens of years. The problem may be illustrated from the effects of sub-lethal stress when imposed on coral by activities such as SCUBA diving. Physical damage to the coral skeleton—by fracturing—may not be intensive enough to be fatal, but it may expose the host to pathogens that eventually cause death some years later. The short term response observed in a trampling experiment by Liddle and Kay was the production of copious mucus which later broke up to reveal "polyps withdrawn into corallites often with tentacles missing, lesions in the tissue between polyps, bleached and empty corallites" (Liddle and Kay 1987:7). Thus, temporal monitoring needs to embrace the life histories of damaged species in order to capture fully the impact of stress. This is a costly requirement, raising the question as to whether the slow response time has already permitted unwitting damage to have crossed the critical threshold.

Subjectivity. The objectivity of a monitoring program may be compromised either intentionally or unintentionally. Ward and Jacoby (1992) describe a strategy for monitoring the ecosystems of an embayment in Australia that was exposed to a variety of anthropogenic stresses. "Valued Ecosystem Components" were identified based on the bay's protection status, as well as conservation, commercial, and recreational values. Five attributes were then identified (recreational, amenity, commercial fisheries, vegetated habitats, faunal inhabitants) with general indicators for each (such as water quality, especially clarity, as an indicator of value of the recreational and amenity attributes). The choice of indicators was generally subjective and reflected human values. For example, plankton were rejected, despite their potential utility as an indicator, because they were not rated highly as valued ecosystem components (they had a low public profile). Such approaches to user defined indicators may be presented as positive stakeholder involvement, but they may also be open to manipulation by vested interests and biased by "popularity".

Coral bleaching may be one such example of popular recognition. Bleaching is caused by the loss of photosynthetic and symbiotic organisms (*zooxanthellae*) which results in discoloration of the coral. It is a very visible response of corals to stress and it has generated public and political concern about the status of reef ecosystems. Therefore, it has a high imputed value as an indicator recommending it under at least one of the ideal specifications. But there are problems with interpretation that may limit its use. Bleaching may in some cases go unperceived by the observer (Brown and Howard 1985), or apparent bleaching events may actually be due to some other disturbance (such as predation) or due to light-adaptation by the coral (Glynn 1993). There is no standardized method of assessing the degree of bleaching in affected organisms and standardization is complicated by the presence of genetically different types of zooxanthellae with different tolerances and responses, as well as varying responses of identical types of zooxanthellae in different hosts (Glynn 1993). Further, the fact that bleaching may reflect a combination of stresses may hinder identification of cause, essential if management is to relieve the stress.

Ambiguities of Expert Interpretation. Part of the difficulty with assembling evidence that has been derived from different sites and under different contexts of stress is that findings may differ for quite legitimate reasons. However, that does not make it any easier to use existing knowledge to evaluate the potential candidate indicators of anthropogenic stress. For example, increasing intensity of diving at a coral reef is normally associated with a decline in the percentage cover of live coral and a decline in the diversity of species. The decline in diversity is accounted for by the differential resistance of coral morphologies to physical pressure, such as trampling. Thus, more massive forms are more resistant than delicate and branching (*foleaceous*) forms. However, Hawkins and Roberts (1992, 1993, 1994) report that after 15 years of intensive tourism pressure on the Red Sea, there appeared to be *no* significant impact on the abundance of different coral morphologies.

Liddle and Kay (1987) explain this paradox by suggesting that the more fragile skeletal forms also have higher recovery rates after damage and this may compensate for their vulnerability. But at Bonaire, in the Caribbean, it was found that coral diversity *increased* at sites where diving was more intensive. The use of "species diversity" as an indicator is highly dependent on how these various responses to stress are explained. Yet it is in the nature of scientific research that such counterfactual observations develop as part of the process of hypothesis testing and theory development. Thus, contrary to the popular notion that scientific intervention is the means to secure certainty, it has to be recognized that the ongoing practice of scientific research also generates ambiguities as differing empirical observations give rise to competing explanations (Giddens 1998). In the longer run, research findings tend to converge; but in the short run, such ambiguity undermines the function of indicators.

Tourist Stress. If the above difficulties were not in themselves insuperable, there is also the final problem of separating tourism stress from other sources of anthropogenic stress. For example, over-fishing to supply the demand of distant markets may be hard to separate from fishing to provide for local restaurants frequented by tourists. Coral mining to provide lime for construction and industrial expansion inland may be inseparable from the demand for raw materials to build hotels at the coast. There is also a difficulty in assigning particular forms of stress to different categories of tourist to enable selective management intervention.

CONCLUSION

This critique of the feasibility of developing bio-indicators has revealed some methodological impediments. These introduce a range of uncertainty into indicator development that arise from the difficulties of differentiating natural from anthropogenic change, the problems of scale, the introduction of subjectivity into a supposedly objective assessment, the ambiguities that arise in interpretation and the difficulties of differentiating tourism induced stress from broader anthropogenic stress. Collectively these threaten the very purpose of indicators. Thus, when can it be said that an effect has "finally" happened? This requires notions of "start" and "finish" that are highly problematic when the baseline from which change has to be measured already bears the combined impacts of tourism, other anthropogenic stress, and an as yet indeterminate level of natural perturbation. The "finish" is also likely to reflect the temporal demands of management rather than the environment, since the cycles through which ecological change becomes apparent seem likely to exceed the one to five year planning horizons over which management typically seeks such information. In short, biological rhythms seem disposed to beat to a different cadence than the demands of tourism management.

These impediments to the construction of bio-indicators constitute a dilemma in which management is faced with the choice of either

waiting for a conclusive outcome to ecological research, running the obvious risk of acting after environmental damage becomes irreversible, or acting without the full benefit of ecological indicators. They introduce a degree of inconclusiveness into interpretation that threatens to undermine the effectiveness of environmental indicators as tools with which to identify and manage the environmental impacts of tourism. Collectively they can be argued to reduce the power of measurement and undermine the utility of explanation. In the absence of certainty about causes and effects, black and white shade off into gray and quantification slides into qualitative judgement. This inconclusiveness undermines the basic function of environmental indicators. In the WTO study, the supposed function of indicators was "above all … to *avoid* risk, or to take *calculated* risks with more complete knowledge of the outcomes" (International Working Group on Indicators of Sustainable Tourism 1993:6). Yet, when there remains so much in question about what constitutes "sufficient" stress, what are its causes and what practical remedies are available for its mitigation, the process of indicator development may be argued to contribute to risk generation as well as risk reduction.

In drawing attention to these various difficulties, this paper has, however, been motivated by more than a concern to simply expose the many hurdles facing those charged with managing tourism in an environmentally sustainable way. Rather, as alluded to in the introduction, the writing out of these difficulties has served to document a deep-seated tension at the heart of the debate on sustainable tourism. The tension is that, as the environment has been progressively remoralized under the thesis of sustainability, tourism's principal vehicle for delivering this is proving to be technical rather than moral. Hence, the pleas recur for instrumental knowledge (such as environmental indicators, carrying capacity data) and the belief continues that there is some "formula" that will permit a balance between advancing social welfare and minimizing environmental degradation. Although not offering many examples that specifically address tourism, it is useful to look briefly at the way that the discipline of environmental economics has coped with this dilemma.

When van den Bergh (1995) approaches the specific issue of tourism's impact on the natural environment, as an environmental economist he seeks to balance social welfare with environmental carrying capacity. He does this by developing a systems model in which various tourism growth and environmental conservation scenarios can be tested. Tourism's growth is represented by indicators such as the number of tourist nights, accommodation land use, water use, congestion, and the like, while the natural environment draws on indices of vegetation (forest and maquis in the case of terrestrial environments) and fauna (seals and fish stocks in the case of the marine environment). The van den Bergh model postulates feedback mechanisms between the changing volume of tourists and impacts on the environment manifested through changes in the indicators listed above. However, as argued earlier, presumptions regarding system feedback links between tourism and the environment prove to be neither necessarily trans-

parent, chronologically determinate, nor tourism specific. At issue here is the degree of risk that has to be attached to the specification of supposed feedback links. Russell (1995), in a retrospective look at the issue of integrating economic and ecological indicators, recognizes the profundity of this risk when he admits that the notion of environmental safety "loses its crispness and appeal when the problem is poorly understood and multidimensional". He points to, what might more fashionably be called, the "globalizing" aspect of ecological impact where the increased scale, dynamism, and system diversity of impacts may simply be beyond the current modeling facilities of environmental economics (1995:23, 18).

This poses the obvious question as to what to do in the face of this indeterminacy. Russell is optimistic that scholarship can eventually supply the remedies for these current technical difficulties. His hope is that the continued interaction between economists and ecologists, encouraged by appropriate career rewards, can chip away at the problems. However, while supporting Russell's aspiration, the continuing search for a technical resolution should not be allowed to mask the moral thrust that lies at the heart of environmental sustainability. In plain terms, the solution to the environmental crisis of tourism does not rest solely with scientific management. The seduction of bio-indicators and environmental models is that they hold out the promise of a purely technical resolution. Under the prevailing character of public discourse, managers can thus feel justified in their frustration at the failure of ecologists and economists to come up with "the" technical answer. If the magic numbers could be produced, they would supply the necessary certainty for planning and management. However, this paper has argued that being able to establish causes and effects with this necessary level of certainty is still some way off and, if only for this reason, "solutions" to the environmental damage from tourism must be found in more responsible approaches to management.

While this may seem a trite conclusion, it is necessary to make it in order to temper the hold that science and rational management have, as dominant "worldviews", over the way that environmental sustainability is currently conceived. The risk involved in placing so much faith in the effectiveness of environmental indicators is not simply due to the kind of shortcomings discussed in this paper but, as a consequence of these shortcomings, being also open to ideological abuse. Under the guise of rational and deliberative processes of decision-making the inconclusiveness or absence of scientific evidence can be used to justify restraint in environmental investment and creativity what Russell aptly terms, "environmental insults". This becomes particularly pertinent at the point where environmental indicators are called upon in arbitration over appropriate uses of land.

One of the common mechanisms for land use regulation is the system of urban and regional planning with its associated procedures for development control. This paper began by arguing that it was in the nature of public discourse to privilege rational debate over emotion and quantitative information over qualitative. This is particularly evident in the institutions for development control where appeals are

considered in a quasi-judicial way. The difficulties experienced with developing bio-indicators suggest that the environment may not be well served in this arena if fuzzy assertions about the ecological impact of tourism have to be pitted against economic "facts" about job and wealth creation. The rationale of capitalism predisposes the institutions charged with land use control to favor development, unless good cause is shown why permission to develop should be refused. In this light the current ambiguities that attend bio-indicators only offer a slender basis for defending the interests of the environment against the continuing global pressures to develop tourism.

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